Endovascular repair of infrarenal aortic aneurysms in octogenarians and nonagenarians

Philipp Geisbüsch, MD,[a,c] **Barry T. Katzen, MD,**[a] **Athanassios I. Tsoukas, MD,**[b] **Dillon Arango,**[a] **Constantino S. Peña, MD,**[a] and **James F. Benenati, MD**[a] *Miami, Fla; and Heidelberg, Germany*

Objective: **The purpose of this report was to present short and midterm results of endovascular aortic aneurysm repair (EVAR) of infrarenal aortic aneurysms in octogenarians and nonagenarians.**
Methods: **Between March 1994 and March 2011, elective EVAR was performed in 967 patients in our institution. This includes 279 patients older than 80 years at the time of the procedure (octogenarians: n = 252, nonagenarians: n = 27). Mean follow-up was 48.4 ± 34.5 months. A retrospective analysis was performed. Survival was calculated using Kaplan-Meier analysis and a survival comparison to patients who underwent EVAR <80 years old (n = 688) was performed. Cox hazard regression analysis was used to assess parameters that influence survival.**
Results: **Technical success was 96% in octogenarians and 85% in nonagenarians. Technical failure in 15 of 279 patients includes primary type I endoleak (n = 6), procedure abortion due to inability to pass the iliac vessels (n = 6), and emergency conversion (n = 3). Thirty-day mortality was significantly higher for patients >80 years old (2.8% vs 1.0%; *P* = .044). Morbidity rates were 11.5% for octogenarians and 7.4% for nonagenarians with predominately cardiopulmonary complications. High-risk patients >80 years old showed a comparable perioperative mortality rate to low-/medium-risk patients >80 years old (2.9% vs 2.5%;*P* = .717), but a significantly higher complication rate (22.5% vs 9.2%; *P* = .0275) and reduced midterm survival with 1-, 3-, and 5-year survival rates of 79% ± SE 7%, 55% ± SE 8%, and 38% ± SE 9% (log-rank test *P* = .03). In high-risk patients age >80 years old, their age did not influence 30-day mortality (2.5% vs 2.7%; *P* = .978) and midterm survival. Survival in octogenarians at 1, 3, and 5 years was 87.9 ± SE 2.1%, 70.9 ± SE 3.0%, and 55.6% ± SE 3.5%, respectively. Survival in nonagenarians at 1 and 3 years was 96.3% ± SE 4% and 60.6% ± SE 10.4%. Higher cardiac (hazard ratio [HR], 1.22; *P* = .038) and renal risk scores (HR, 1.59; *P* = .0016), chronic obstructive pulmonary disease (HR, 1.56; *P* = .032), and anemia (HR, 2.1; *P* < .001) influenced midterm survival.**
Conclusion: **EVAR in octogenarians and nonagenarians is associated with a significantly higher but still low perioperative mortality compared to younger patients. Midterm survival in octogenarians and nonagenarians, although significantly lower than in younger patients, is still acceptable, indicating that age >80 years should not be an exclusion criteria for EVAR. Even high-risk patients >80 years can be treated safely with a low perioperative mortality and comparable midterm outcome to younger high-risk patients. (J Vasc Surg 2011;54:1605-13.)**

The elderly are one of the fastest growing population segments in many industrial countries. For the United States, the number of people aged >85 years in 2050 is estimated at 21 million, an increase from 1.5% to 5% of the total population.[1] Similar findings are reported for the European Union, where the number of people aged >80 years is projected to almost triple from 21.8 million in 2008 to 61.4 million in 2060.[2] As the occurrence of abdominal aortic aneurysms (AAAs) is age related, there will be a growing number of patients older than 80 years seeking treatment for an AAA in the future.[3,4] At present, endovascular aortic aneurysm repair (EVAR) is the first-line treatment option for patients with infrarenal aortic aneurysms in many centers. Although excellent results for open surgery in octogenarians have been reported, EVAR seems especially appealing in elderly patients, generally considered at high risk for open surgical aneurysm repair.[5] Although EVAR is certainly technically feasible in octogenarians/nonagenarians, questions remain regarding the indication for treatment while balancing the natural course of the disease and life expectancy against the short-term (mortality, morbidity) and midterm (eg, reintervention rate, cost-effectiveness) complications of EVAR. The purpose of this study was, therefore, to report and analyze our short- and mid- to long-term results of EVAR in octogenarians and nonagenarians in a large, continuous patient cohort. We further aimed to identify possible risk factors that might help to improve patient selection in this subgroup of patients.

From the Division of Vascular and Interventional Radiology[a] and the Division of Vascular Surgery,[b] Baptist Cardiac and Vascular Institute, Miami; and the Department of Vascular and Endovascular Surgery, Ruprecht-Karls University, Heidelberg.[c]

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Reprint requests: Philipp Geisbüsch, MD, BCVI Cook Research Scholar, University of Heidelberg and the Department of Vascular and Endovascular Surgery, Baptist Cardiac and Vascular Institute, Baptist Hospital of Miami, 8900 North Kendall Drive, Miami, FL 33176 (e-mail: philippgeisbuesch@gmx.de).

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METHODS

Patient population. Between March 1994 and March 2011, EVAR of an infrarenal aortic aneurysm was performed in 958 patients in our institution. This includes 279 patients older than 80 years at the time of the procedure (octogenarians: n = 252, nonagenarians: n = 27), which

Table I. Demographics, risk factors, and comorbidities of all patients older than 80 years undergoing elective EVAR (n = 279)

	Total (n = 279)	*Octogenarians (n = 252)*	*Nonagenarians (n = 27)*
Age (years)	84.6 ± 3.4	83.9 ± 2.6	91.6 ± 1.5
Gender (male)	238 (85)	213 (84)	25 (93)
BMI (kg/m^2)	26.1 ± 3.7	26.1 ± 3.7	25.5 ± 3.2
Baseline hemoglobin (g/dL)	13.1 ± 1.7	13.1 ± 1.7	12.5 ± 1.4
Baseline hematocrit (%)	39.1 ± 5.1	39.2 ± 5.2	37.8 ± 4.0
Anemia	116 (42)	100 (40)	16 (59)
Baseline creatinine clearance[a] (mL/min)	42.4 ± 14.9	43.2 ± 14.8	34.9 ± 11.2
Stage of chronic kidney disease			
1 (GFR[a] 130-90 mL/min)	—	—	—
2 (GFR[a] 90-60 mL/min)	35	34	1
3 (GFR[a] 60-30 mL/min)	187	172	15
4 (GFR[a] 30-15 mL/min)	49	38	11
5 (GFR[a] <15 mL/min)	7	7	—
Diabetes mellitus	36 (13)	34 (13)	2 (7)
Hyperlipidemia	147 (53)	135 (54)	12 (44)
Hypertension	246 (88)	221 (88)	25 (93)
COPD	90 (32)	84 (33)	6 (22)
History of smoking	200 (72)	183 (73)	17 (63)
History of cerebrovascular disease	54 (19)	50 (20)	4 (15)
History of PAOD	101 (36)	91 (38)	10 (37)
CAD	106 (38)	96 (38)	10 (37)
ASA score			
I	—	—	—
II	2 (1)	2 (1)	—
III	221 (79)	206 (82)	15 (55)
IV	56 (20)	44 (17)	12 (45)
SVS-AAVS medical comorbidity grading system			
Cardiac risk level			
0	62 (22)	60 (24)	2 (7)
1	34 (12)	33 (13)	1 (4)
2	165 (59)	142 (56)	23 (85)
3	18 (6)	17 (7)	1 (4)
Renal risk level			
0	203 (73)	184 (73)	19 (70)
1	64 (23)	56 (22)	8 (30)
2	9 (3)	9 (3)	—
3	3 (1)	3 (1)	—
Pulmonary risk level			
0	134 (48)	118 (47)	15 (59)
1	83 (30)	76 (30)	6 (22)
2	42 (15)	39 (15)	3 (11)
3	20 (7)	18 (7)	2 (7)

ASA, American Society of Anesthesiologists; *BMI,* body mass index; *CAD*, coronary artery disease; *COPD,* chronic obstructive pulmonary disease; *EVAR,* endovascular aortic aneurysm repair; *GFR,* glomerular filtration rate; *PAOD,* peripheral arterial occlusive disease; *SVS-AAVS,* Society for Vascular Surgery/American Association for Vascular Surgery.
Values are given as n (%) or mean ± SD.
[a]Calculated by Cockcroft-Gault-Formula.

represent the study population (Table I). Patients with ruptured aortic aneurysms, reinterventions after previous EVAR, and patients requiring fenestrated stent grafts were excluded from this analysis. Generally, in consensus with the practice guidelines, the minimum threshold for elective EVAR procedures was a maximum aneurysm diameter of >5.5 cm, but even in AAAs >5.5 cm, treatment decision was individually based considering comorbidities and the patients' will.[6] Median aneurysm diameter for octogenarians was 60 mm (range, 5.5-9 cm), 71 mm for nonagenarians (range, 5.5-10 cm), and 6.4 cm (range, 5.5-11 cm) for high-risk patients/American Society of Anesthesiology (ASA) class IV patients. For preoperative risk stratification, the patients were scored using the ASA classification and the medical comorbidity grading system suggested by the Ad Hoc Committee for Standardized Reporting Practices in Vascular Surgery of the Society for Vascular Surgery/American Association for Vascular Surgery.[7] This medical comorbidity grading system is a score that involves age, cardiac, pulmonary, and renal-related risk factors (level 0/1 = low/minimal risk to level 2/3 = moderate/high-risk level). Demographics, risk factors, and comorbidities of the patients are given in Table I. A total of 40 patients were considered high-risk patients, defined by high cardiac, re-

Table II. Procedure-specific data

	Total (n = 279)	*Octogenarians (n = 252)*	*Nonagenarians (n = 27)*
Type of anesthesia			
Local	94 (34)	81 (32)	13 (48)
Regional	159 (57)	148 (59)	11 (41)
General	26 (9)	23 (9)	3 (11)
Type of arterial access			
Cut down/cut down	202 (72)	180 (71)	22 (81)
Cut down/percutaneous	66 (24)	63 (25)	3 (11)
Percutaneous/percutaneous	11 (4)	9 (4)	2 (8)
Operating time (minutes)	158 ± 69	158 ± 71	158 ± 61
Fluoroscopic time (minutes)	28 ± 13	28 ± 13	31 ± 15
Contrast volume (mL)	165 ± 74	164 ± 75	170 ± 73

Table III. Thirty-day outcome of 279 patients older than 80 years undergoing elective endovascular repair of an infrarenal aortic aneurysm

	Total (n = 279)	*Octogenarians (n = 252)*	*Nonagenarians (n = 27)*
Thirty-day mortality	8 (2.8)	8 (3.2)	0
Perioperative morbidity	29 (10.3)	27 (10.7)	2 (7.4)
Cardiac complications	9 (3.2)	9 (3.5)	0
Respiratory complications	4 (1.4)	4 (1.6)	0
Renal complications	8 (2.8)	8 (3.2)	0
Access site complications	7 (2.5)	5 (2)	2 (7.4)
Pancreatitis	1 (0.4)	1 (0.4)	0
MOF	1 (0.4)	1 (0.4)	0
Stroke	2 (0.7)	2 (0.7)	0
DVT	1 (0.4)	1 (0.4)	0
Peripheral embolization	1 (0.4)	0	1 (3.7)
Surgical conversion	3 (1.1)	2 (0.7)	1 (3.7)
Aborted procedure	6 (2.1)	4 (1.6)	2 (7.4)
Limb occlusion	2 (0.7)	2 (0.7)	0
Endoleak			
Type I	6 (2)	5 (2)	1 (3.7)
Type II	40 (14)	38 (15)	2 (7.4)
Type III	—	—	—
Type IV	29 (10)	26 (10)	3 (11)
ICU stay n (%)	23 (8)	19 (7.5)	4 (15)
Hospital stay (days)	3 (1-106)	3 (1-106)	3 (2-13)

DVT, Deep vein thrombosis; *ICU,* intensive care unit; *MOF,* multiorgan failure.
Values are given as n (%) or median (range).

nal, and pulmonary risk levels (6%, 0.7%, and 7%, respectively). A survival comparison to all patients <80 years (n = 688) that underwent EVAR during the same time period in our institution was performed. This younger patient cohort included a comparable proportion of high-risk patients (14% vs 11%; $P = .222$).

Procedure. All procedures were performed with an interdisciplinary team involving vascular surgeons, interventional radiologists, and anesthesiologists in an angiography suite. Procedural details are given in Table II. The following stent grafts were used: Talent (Medtronic, Santa Rosa, Calif; n = 81), Excluder (W. L. Gore & Associates, Flagstaff, Ariz; n = 77), AneuRx (Medtronic; n = 36), Zenith (Cook, Bloomington, Ill; n = 43), Ancure (Guidant, Menlo Park, Calif; n = 35), Vanguard (Boston Scientific, Natick, Mass; n = 4), and Trivascular (Boston Scientific; n = 3). The majority of patients were treated under locoregional/regional anesthesia (91%) with a surgical cut down (72%).

Follow-up. Patients were routinely followed by our institution and follow-up included postoperative computed tomographic angiography (CTA) before discharge/30 days, and CTA/magnetic resonance angiography 6 and 12 months postoperatively and annually thereafter. Mean follow-up was 48.4 ± 34.5 months for the total study population, 49.7 ± 35.3 months for octogenarians, and 36.1 ± 22.2 months for nonagenarians. The Social Security Death Index (http://ssdi.rootsweb.com) was used to ascertain mortality as of March 1, 2011.

Definitions and statistical analysis. Technical success and endoleaks were defined according to the reporting standards for EVAR.[8] Anemia was defined according to the World Health Organization definition as a hemoglobin level <13 g/dL in men and <12 g/dL in women.[9] Pulmonary complications were defined as pneumonia, required pharmacologic or ventilator support, and worsening of pre-existing pulmonary impairment. Renal failure was defined as required temporary or permanent dialysis. Ret-

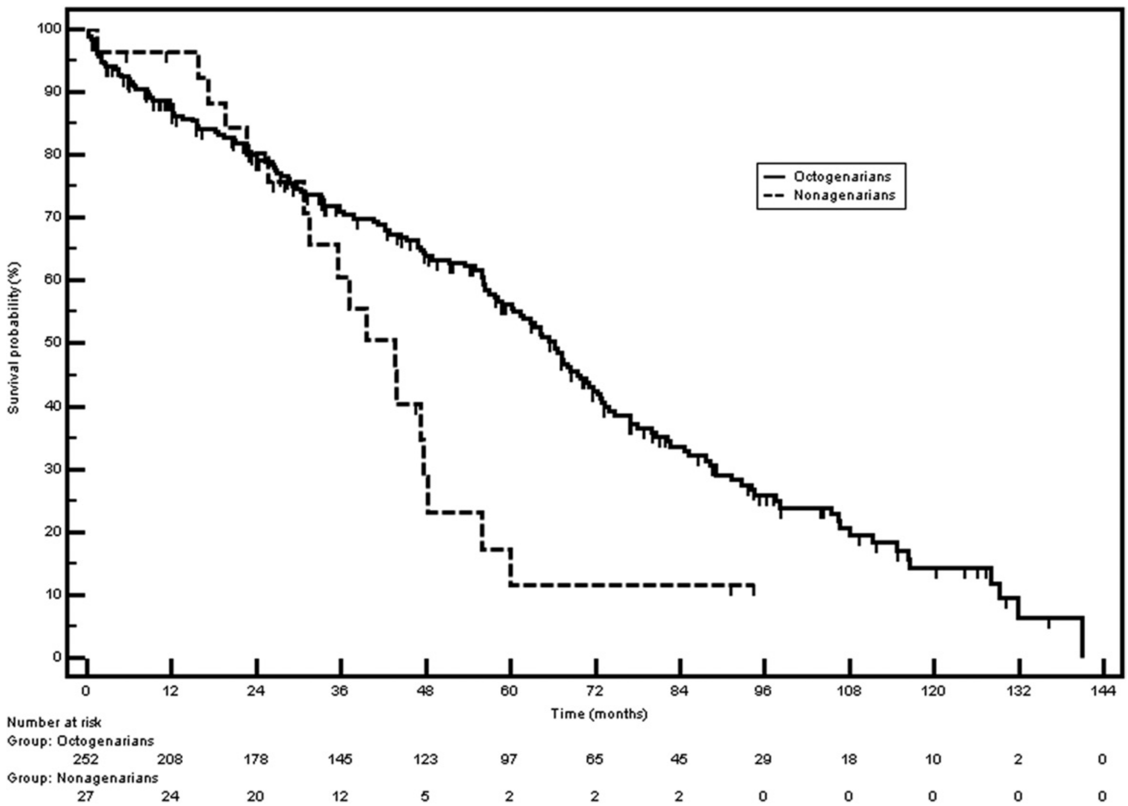

Fig 1. Kaplan-Meier survival analysis of octogenarians (n = 252) and nonagenarians (n = 27) that received endovascular aortic aneurysm repair (EVAR) in our institution.

rospective analysis of the data was performed. Institutional review board approval for retrospective review of the study patients was obtained. Data are expressed as mean ± SD or median (range). Survival estimates were generated using the Kaplan-Meier analysis and the log-rank test was used for survival comparisons. The χ^2 test was used for the comparison of categorical variables. Cox hazard regression analysis was used to assess parameters that influence survival. All statistical analysis was performed using MedCalc (version 9.5.2, MedCalc Software, Mariakerke, Belgium). A *P* value $< .05$ was defined statistically significant.

RESULTS

Technical success in the total study population was achieved in 264 of 279 patients (94.6%) and was 96% (241 of 252 patients) in octogenarians and 85% (23 of 27 patients) in nonagenarians. Technical failure in 15 of 279 patients includes six patients with a primary type I endoleak, six patients with an aborted procedure due to inability to pass the iliac vessels with the endograft, and three patients with emergency conversion (described below). All patients with type I endoleaks were detected on the postoperative CTA and the patients received successful reinterventions (Palmaz stent; Cordis Endovascular, Warren, NJ; n = 2; proximal extension cuff, n = 4).

Mortality and morbidity. The 30-day mortality was 2.8% for the total study population with all eight deaths occurring in octogenarians (3.2%). Cause of death was myocardial infarction (n = 3), pneumonia (n = 1), multiorgan failure after emergency conversion (n = 1), and pancreatitis with cardiac arrest (n = 1). An additional two patients died after an initial uneventful course (no complication, no endoleak) on the 26th and 27th postoperative day after discharge. The cause of death was stroke in one patient and remained unknown in the other patient. Perioperative complications occurred in 31 of 279 patients (11%). The morbidity rate was 11.5% for octogenarians and 7.4% for nonagenarians (Table III). Cardiac complications were seen in nine patients (3× myocardial infarction, 1× congestive heart failure, and 5× arrhythmia). Pulmonary complications (n = 4) included pneumonia (n = 2) and respiratory failure (n = 2) due to worsening of a preexisting chronic obstructive pulmonary disease (COPD). A total of eight patients required temporary (n = 3) or permanent dialysis (n = 5). Access site complications included rupture of the access vessel (n = 2), groin hematoma requiring transfusion/surgical revision (n = 2), and groin infection causing intravenous antibiotic therapy and surgical revision (n = 2). Limb occlusions occurred in two patients (0.7%) on postoperative day 9 and 30 and were

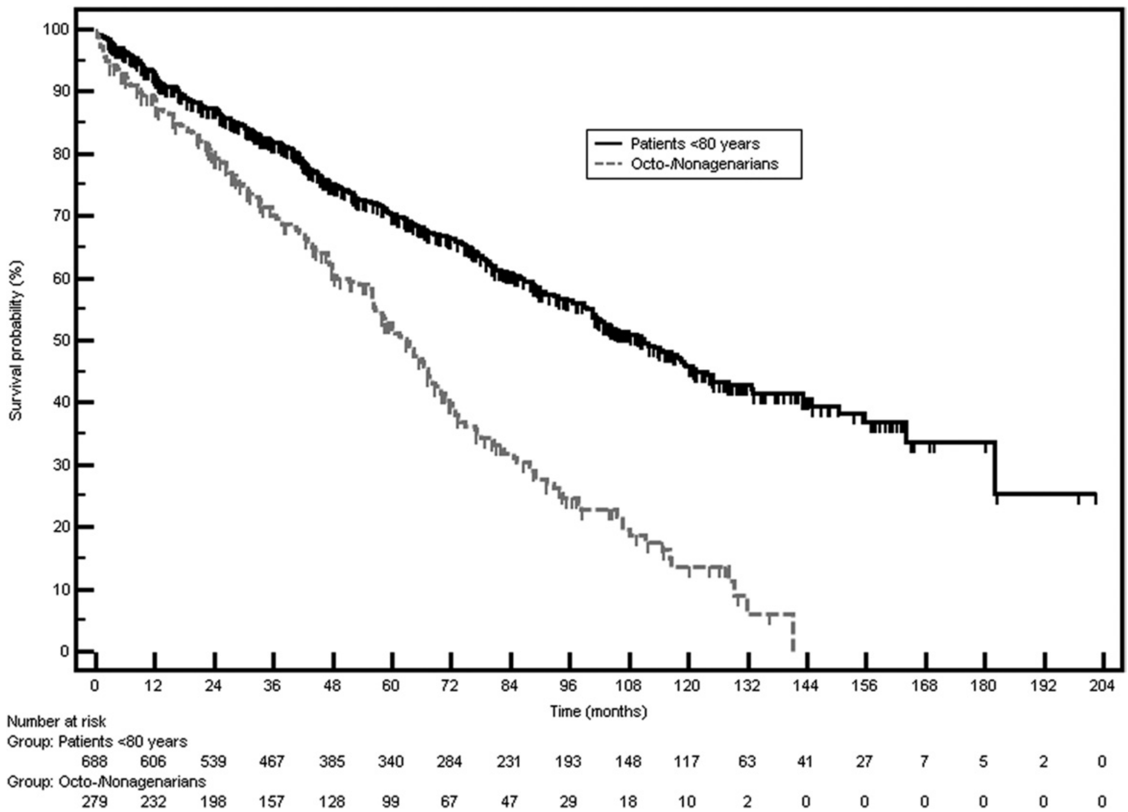

Fig 2. Kaplan-Meier survival analysis shows a significantly reduced midterm survival for patients >80 years old (n = 279) compared to younger patients undergoing elective endovascular aortic aneurysm repair (EVAR; log-rank test $P <$ .0001).

Table IV. Comparison of 30-day mortality and midterm survival of patients >80 years (n = 279) and patients <80 years (n = 688) that underwent elective EVAR

Parameter	*Patients >80 years (n = 279)*	*Patients <80 years (n = 688)*	P *value*
Thirty-day mortality	2.8%	1.0%	.044
Midterm survival[a]			
1 year	87% ± SE 2%	91% ± SE 1%	
2 years	79% ± SE 2%	87% ± SE 1%	<.0001[a]
3 years	70% ± SE 3%	81% ± SE 2%	
5 years	52% ± SE 3%	70% ± SE 2%	

EVAR, Endovascular aortic aneurysm repair.
[a]Kaplan-Meier survival analysis (log-rank test).

successfully treated with thrombectomy and stent graft placement.

Transfusion of red blood cells was necessary in 48 patients (17%). Emergency conversion was performed in three patients (1%). This includes two patients with intraoperative aortic/iliac rupture (both patients survived 4, respectively, 6.5 years postoperative) and one patient with bilateral accidental coverage of the renal artery that could not be resolved by endovascular bailout techniques (patient died due to multiorgan failure on the second postoperative day). All these cases showed challenging aneurysm morphologies with respect to small access vessels (n = 1) and short/angulated neck (n = 2).

Midterm results. Secondary endoleaks were observed in 10 patients (3.6%). This includes six patients with type I endoleaks, three patients with type II endoleaks, and one patient with endotension. Reintervention was necessary in 30 of 279 patients (10.7%) with no significant difference between octogenarians (10.7%) and nonagenarians (11%). Causes for reintervention were primary (n = 6) or secondary (n = 6) type I endoleaks, type II endoleaks (n = 13), endotension (n = 1), graft limb occlusions (n = 2), caudal graft migration (n = 1), and renal artery impairment by the endograft (n = 1). Kaplan-Meier analysis of survival in octogenarians showed 1-, 3-, and 5-year survival rates of 87.9 ± SE 2.1%, 70.9 ± SE 3.0%, and 55.6% ± SE 3.5%, respectively. Survival in nonagenarians at 1, 3, and 5 years was 96.3% ± SE 4%, 60.6% ± SE 10.4%, and 15% ± SE 7.5% (Fig 1). During follow-up, 166 patients died (59%). In three of 279 patients (1.1%), death was related to the aneurysm, in 66 of 166 patients (40%), it was attributed to the comorbidities of the patient, and in 97 of 166 patients (58%), the actual cause of death remained unknown. In

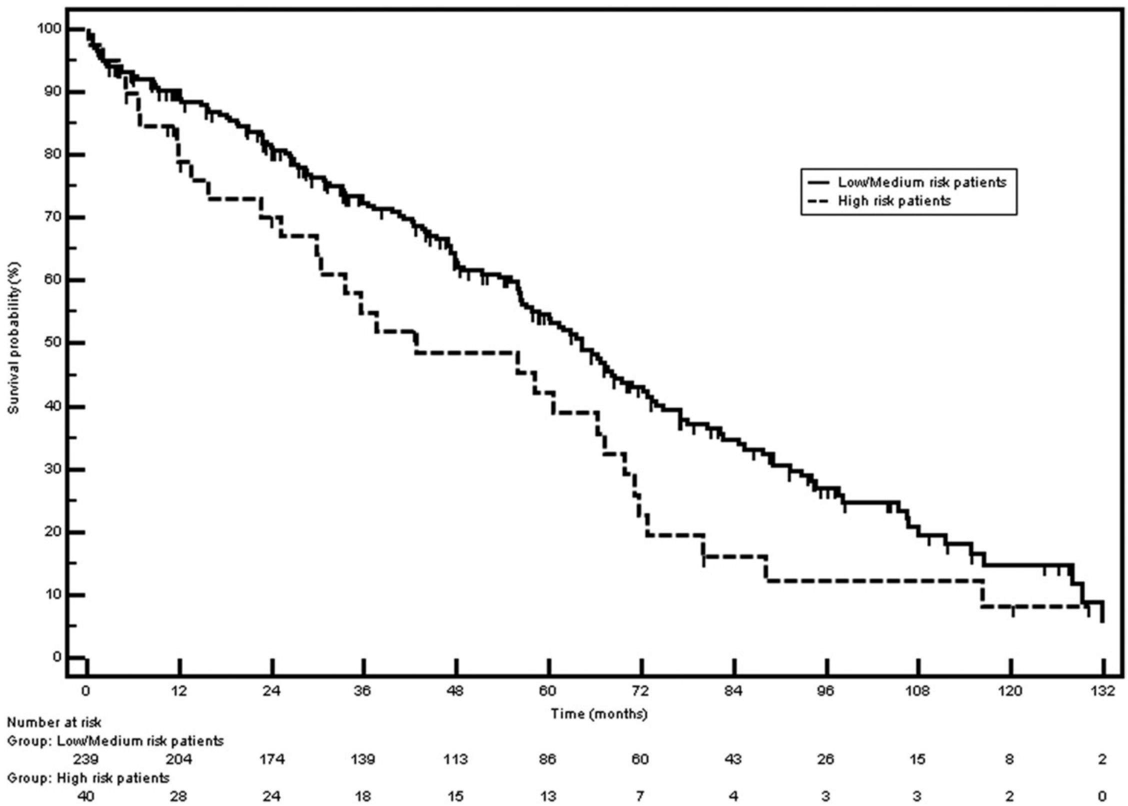

Fig 3. Kaplan-Meier survival analysis shows a significantly reduced midterm survival for high-risk patients >80 years old (n = 40) compared to low-/medium-risk patients >80 years old (log-rank test *P* = .0399).

Table V. Comparison of 30-day mortality and midterm survival of high-risk (n = 40) and low-/medium-risk (n = 239) patients >80 years old undergoing elective endovascular repair of an infrarenal aortic aneurysm

Parameter	*High-risk patients >80 years (n = 40)*	*Low-/moderate-risk patients <80 years (n = 239)*	P *value*
Thirty-day mortality	2.5%	2.9%	.717
Midterm survival[a]			
1 year	79% ± SE 7%	90% ± SE 2%	
2 years	70% ± SE 8%	81% ± SE 3%	.0399[a]
3 years	55% ± SE 8%	72% ± SE 3%	
5 years	38% ± SE 9%	53% ± SE 4%	

[a]Kaplan-Meier survival analysis (log-rank test).

these 97 patients, the median time interval between death and last imaging follow-up was 23 months (range, 1-106 months).

The group of octogenarians/nonagenarians (n = 279) was compared to all patients <80 years old (n = 688) that underwent EVAR during the same time period in our institution. Patients >80 years old showed a significantly higher 30-day mortality rate (2.8% vs 1.0%; *P* = .044) and significantly lower survival rate than the younger cohort during follow-up (Table IV; Fig 2).

High-risk patients. The mortality rate for high-risk octogenarian/nonagenarian patients (n = 40) was 2.5% with no statistical significant difference (*P* = .717) to low-/moderate-risk octogenarian/nonagenarian patients (2.9%). However, high-risk patients showed a significantly higher complication rate (22.5% vs 9.2%; *P* = .0275) and had a significantly reduced midterm survival (Table V; Fig 3). For patients classified as ASA IV, no significant difference in mortality (3.5% vs 2.6%; *P* = .9246) or morbidity (19% vs 13%; *P* = .895) was observed. A comparison of high-risk patients >80 years old with high-risk patients <80 years old showed no significant difference in 30-day mortality (2.5% vs 2.7%; *P* = .978) or midterm survival (Table VI; Fig 4).

Cox hazard regression analysis, including cardiac, pulmonary, and renal risk levels showed anemia (hazard ratio [HR], 2.1; *P* < .001) as the strongest influence factor on survival (Table VII).

DISCUSSION

The present series shows that endovascular repair of infrarenal aortic aneurysms in octogenarians and nonagenarians is associated with a significantly higher, but still low perioperative mortality compared to younger patients (2.8% vs 1%; *P* = .044). High-risk patients >80 years old showed comparable perioperative mortality (2.5%), but a

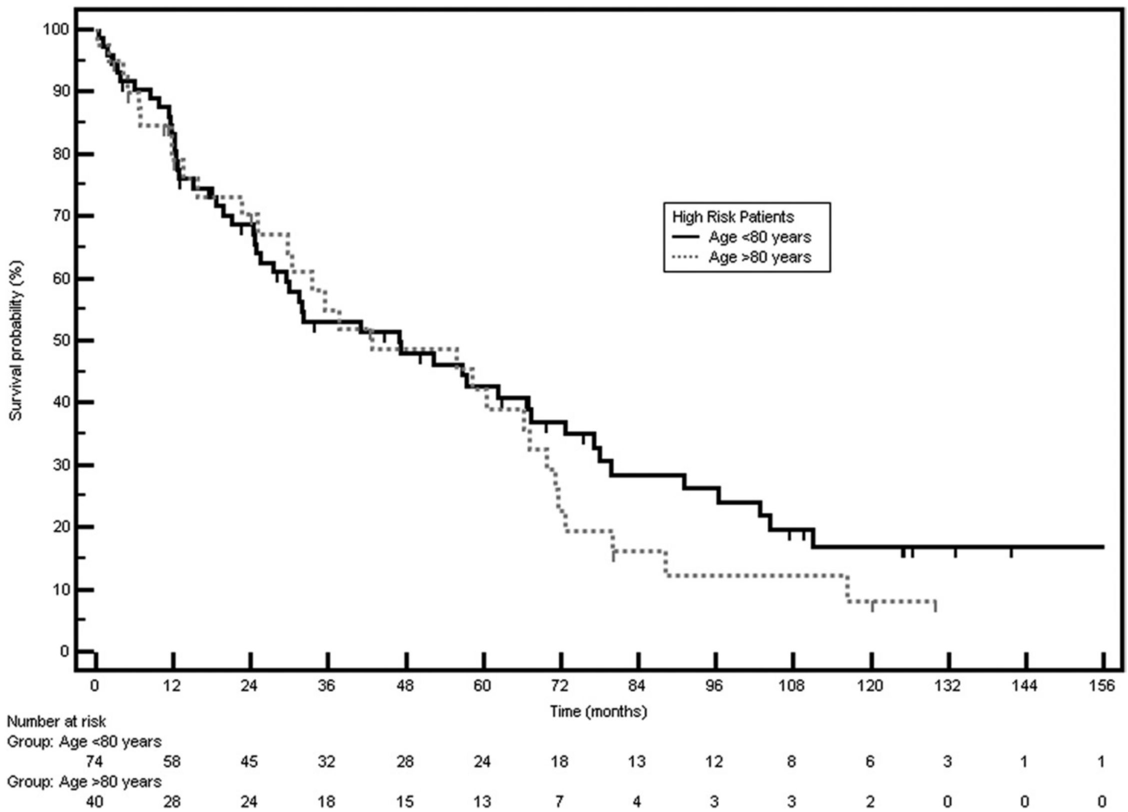

Fig 4. Kaplan-Meier survival analysis shows no significant difference in midterm survival for high-risk patients >80 years old (n = 40) compared to high-risk patients <80 years old (log-rank test *P* = .428).

Table VI. Comparison of 30-day mortality and midterm survival of high-risk patients >80 years old (n = 40) and <80 years old (n = 74) undergoing elective endovascular repair of an infrarenal aortic aneurysm

Parameter	*High-risk patients >80 years*	*High-risk patients <80 years*	P *value*
Patients	40/279 (14%)	74/688 (11%)	.222
Thirty-day mortality	2.5%	2.7%	.978
Midterm survival[a]			
1 year	78% ± SE7%	83% ± SE4%	
2 years	70% ± SE8%	68% ± SE6%	.428[a]
3 years	54% ± SE8%	53% ± SE6%	
5 years	39% ± SE9%	42% ± SE6%	

[a]Kaplan-Meier survival analysis (log-rank test).

Table VII. Multivariable Cox regression analysis for prediction of mortality during long-term follow-up of 279 consecutive patients older than 80 years undergoing elective endovascular abdominal aortic aneurysm repair

Variable	*Adjusted[a] HR*	*95% CI*	P *value*
Cardiac risk score	1.22	1.01-1.47	.038
Pulmonary risk score	1.09	0.89-1.32	.371
Renal risk score	1.59	1.19-2.13	.0016
Anemia	2.12	1.51-2.99	.00001
Age (per year)	1.05	1.00-1.10	.041
COPD	1.56	1.03-2.35	.032

CI, Confidence interval; *COPD,* chronic obstructive pulmonary disease; *HR,* hazard ratio.
[a]Adjusted for age, gender, anemia, cardiac, pulmonary, and renal risk score, history of cancer, hyperlipidemia, diabetes mellitus, smoking, COPD, cerebrovascular disease, coronary artery disease, hypertension, statin use, and type of anesthesia (general anesthesia).

significantly higher complication rate and significantly reduced midterm survival than low-/medium-risk patients >80 years old. Age did not influence the outcome in high-risk patients. High-risk patients older and younger than 80 years old showed a comparable perioperative mortality and midterm survival. Reported mortality rates for octogenarians after EVAR in larger series vary between 1% and 5% and are thus in line with our results (3.2%).[10-14] Consistent with our findings, these series describe cardiopulmonary complications as the predominant cause of perioperative death, which underlines the necessity for a rigorous preoperative cardiopulmonary evaluation and optimization of the patients. Cardiac (3.2%) and renal (2.8%) complications in our series are both within the reported range of the literature (1.7% to 7.5% for cardiac complica-

Table VIII. Selected studies reporting outcome of EVAR in nonagenarians

Study	*Patients*	*Thirty-day mortality*	*Survival data*
Goldstein et al[16]	24	4.2%	1-year survival: 83% 2-year survival: 64% 3-year survival: 50%
Prenner et al[18]	24	8.3%	1-year survival: 83.3% 5-year survival: 19.3%
Jim et al[17]	18	5.6%	Mortality at 1 year: 41.2% Mortality at 2 years: 58.3%
Miami experience	27	0%	1-year survival: 96.3% 3-year survival: 60.6%

EVAR, Endovascular aortic aneurysm repair.

tions and 3.5% to 6% for renal complications).[11,12] However, we observed a lower rate of pulmonary complications (1.8%) than reported in the European Collaborators on Stent/Graft Techniques for Aortic Aneurysm Repair (EUROSTAR) analysis (4.5%) and the series by Fonseca et al[11] (5.1%). Two factors might have contributed to this result. First, both series report a higher rate of patients with pre-existing COPD/impaired pulmonary function, and second, the vast majority of patients in these series were treated under general anesthesia (70% in the EUROSTAR data). In our series, general anesthesia was only used in 10% of the patients and, given our findings, we would recommend the use of local anesthesia in these patients. This large single-center study of octogenarians and nonagenarians with a mean follow-up of 48.4 months allows midterm survival analysis, which indicates an acceptable midterm survival in both patient cohorts. Octogenarians showed a 5-year survival rate of 55% which is comparable to the EUROSTAR data (n = 697 octogenarians, mean follow-up 14 months) that showed a 64% survival at 5 years.[12] Recently, Fonseca et al[11] published their excellent results of a cohort of 117 octogenarians and showed a 5-year survival rate of 91.6%, which may represent a selection bias toward a very robust octogenarian patient cohort as stated by the authors. Recently, the US Census Bureau reported a life expectancy of 5.7 years at the age of 85 years. In our cohort (median age, 85 years), the median survival for patients >80 years was 5.2 years (range, 0-11.6 years).[15] All these data indicate that these patients might have a sufficient life expectancy to benefit from the prophylactic nature of elective AAA repair. Perioperative results and survival data of selected large series of nonagenarians, including ours, are summarized in Table VIII.[16-18] Technical success was only achieved in 23 of 27 nonagenarians (85%), which might reflect "pushing the envelope" to avoid open repair in these patients, because technical failure included abortion of the procedure for iliac rupture (n = 1) or inability to pass the device through the iliac artery, aortic rupture (n = 1) after stent graft deployment (conversion), and a type I (n = 1) endoleak (successful reintervention).

A subgroup of patients that warrant attention are high-risk patients >80 years old, because indication for treatment is especially controversial in these patients. Our data suggest that even high-risk patients >80 years can be treated with low perioperative mortality (2.5%). High-risk patients >80 years had a significantly higher complication rate (n = 9 of 40; 22.5%), but four of nine patients had nonsystemic (access, limb obstruction, bleeding) complications. High-risk patients showed a significantly reduced midterm survival. However, 3- and 5-year survival rates of 54% ± SE 8% and 39% ± SE 9% and a median survival of 3.5 years (range, 0-10.8 years) might indicate that even high-risk patients should not generally be excluded from EVAR and that further risk stratification tools for this subgroup are needed. One aim of this study was to identify risk factors that influence survival in this patient cohort and thus help to improve future patient selection. Besides a higher cardiac and renal risk score, the presence of COPD (HR, 1.56; P = .032) and anemia (HR, 2.12; P < .001) influenced survival. In this series, anemia was present in 42% of the patients and preoperative or postoperative transfusion of red blood cells was necessary in a high proportion of patients (17%), a finding confirmed by other series.[11] We have previously proven anemia to be associated with aneurysm size and decreased long-term survival after EVAR, and this series also suggests the role for anemia as a risk stratification tool in elderly patients with AAA.[19,20] Given the demographical development in most industrial countries, there is no doubt that more and more elderly patients with AAAs will seek treatment in the future. The decision to treat these patients, especially nonagenarians, remains at this point very individual and controversial. It is dependent on patient comorbidities, aneurysm size, and, importantly, the patients' and families' desires. The mean diameter of the aneurysms that were treated in this series was 70 mm for nonagenarians. Balancing the risk of aneurysm rupture against the life expectancy of these patients, a higher than 5.5 cm aneurysm diameter might be adequate as a threshold for treatment in this subgroup of patients, especially in high-risk patients with the aforementioned comorbidities. This study does not have a conservative control group of patients >80 years old with AAAs and ideally similar comorbidities and, thus cannot define an AAA diameter threshold at which octogenarians or nonagenarians benefit from EVAR. At present, we tend to exclude patients that combine high medical and high anatomic risk factors from EVAR, which might change in the future with improving endograft technology.

CONCLUSIONS

EVAR in octogenarians and nonagenarians is associated with a significantly higher, but still low perioperative mortality compared to younger patients. Midterm survival in octogenarians and nonagenarians, although significantly lower than in younger patients, is still good, indicating that age >80 years should not be an exclusion criteria for EVAR. Even high-risk patients >80 years old can be treated safely with a low perioperative mortality and acceptable midterm outcome, which are comparable to younger high-risk patients. Higher cardiac and renal risk scores, COPD, and anemia influence survival and should be incorporated in specific risk stratification tools for this growing subgroup of patients with AAAs.

AUTHOR CONTRIBUTIONS

Conception and design: PG, BK
Analysis and interpretation: PG
Data collection: PG, AT, JB, DA, CP
Writing the article: PG
Critical revision of the article: BK, AT, JB, CP
Final approval of the article: PG, BK
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